Government of South Australia
Department of Water, Land and Biodiversity Conservation

The Living Murray
One River. One Life. Our Future.

Loveday Basin Conceptual Model and Rehabilitation Workshop

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Knowledge and Information
Department of Water, Land and Biodiversity Conservation

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FOREWORD

South Australia’s water resources are fundamental to the economic and social wellbeing of the State. Water resources are an integral part of our natural resources. In pristine or undeveloped situations, the condition of water resources reflects the equilibrium between rainfall, vegetation and other physical parameters. Development of surface and groundwater resources changes the natural balance and causes degradation. If degradation is small, and the resource retains its utility, the community may assess these changes as being acceptable. However, significant stress will impact on the ability of a resource to continue to meet the needs of users and the environment. Degradation may also be very gradual and take some years to become apparent, imparting a false sense of security.

Management of water resources requires a sound understanding of key factors such as physical extent (quantity), quality, availability, and constraints to development. The role of the Knowledge and Information Division of the Department of Water, Land and Biodiversity Conservation is to maintain an effective knowledge base on the State’s water resources, including environmental and other factors likely to influence sustainable use and development, and to provide timely and relevant management advice.

Ben Bruce
Acting Director, Knowledge and Information
Department of Water, Land and Biodiversity Conservation

CONTENTS

ATTENDEES

Attendees

Mr. David Cresswell (Principal Hydrologist) – DWLBC

Dr. Amy George (Knowledge Broker) – DWLBC/CRC FE

Mr. Ashley Greenwood (Facilitator/Program Manager – River Murray) – DWLBC

Mr. Nigel Hayball (Wetland Management Project Officer) – DWLBC

Mr. Jason Higham (MDBC Native Fish Strategy Co-ordnator) – PIRSA

Dr. Andrew Keogh (Project Coordinator, Environmental Works and Measures Program) – MDBC

Dr. Sebastien Lamontagne (Research Scientist) – CRC LEME

Dr. Lisa Mensforth (Principal Policy Officer) – DWLBC

Dr. Jason Nicol (Senior Research Officer) – SARDI

Dr. Daryl Nielsen (Research Scientist) – MDFRC

Dr. Nick Souter (Senior Ecologist) – DWLBC

Mrs. Tracy Steggles (Project Officer – Wetland Management) – RMCWMB

Mr. Paul Stribley (Project Manager) – BBLAP

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Contributors

Dr. Rob Burton (Managing Director) - Burton Science, Business & Environment

Mr. Steve Barnett (Principal Hydrogeologist) – DWLBC

Acronyms

BBLAP – Berri Barmera Local Action Plan

CRC FE – Cooperative Research Centre for Freshwater Ecology

CRC LEME – Cooperative Research Centre for Landscape Environments and Mineral Exploration

DWLBC – Department of Water, Land and Biodiversity Conservation

MDFRC – Murray Darling Freshwater Research Centre

PIRSA – Primary Industries and Resources, South Australia

RMCWMB – River Murray Catchment Water Management Board

SARDI – South Australian Research and Development Institute

1. INTRODUCTION

Historically (prior to Locks) Loveday Basin appears to have been a semi-permanent backwater, inundated annually. During these periods of inundation significant exchange of water and entrained materials, including salt, would have occurred. The construction of Locks along the river has significantly changed the wetting and drying regime. The Loveday Basin was established as a disposal basin in 1972 (Map 1) by banking off the downstream connection (now the Northern Inlet) in order to isolate the basin. This was undertaken in order to relieve pressure on the Cobdogla Disposal Basin by redirecting the majority of the drainage water previously entering the Cobdogla Disposal Basin and Lake Bonney into the new Loveday Disposal Basin.

Due to community interest and the improvements in irrigation efficiency that have resulted in a reduction in the volume of drainage water being captured by these basins, it is now realistic to examine rehabilitation options for the Loveday Basin.

1.1 Workshop Background

The rehabilitation of Loveday Basin has been discussed for a number of years. During this time a range of rehabilitation options have been proposed but not implemented due to a variety of social and scientific concerns, not least of which has been the lack of integration across technical disciplines and an associated narrow focus.

An interdisciplinary workshop was held to enable an analysis of the rehabilitation options available at this site from as wide a scientific perspective as possible, while incorporating social perspectives and local knowledge. The rehabilitation options were developed, through the analysis of limiting factors and the development of a conceptual model.

The aims of the workshop were intentionally very broad. To provide a better defined structure they were prioritised by a three-tiered ranking. These aims were designed to enable the participants to address the specific concerns of a range of disciplines while enabling the focus to be maintained on appropriate rehabilitation options.

Primary Aims

1. Identify key processes
2. Identify limiting factors
3. Develop conceptual model of the Loveday Basin under current conditions
4. Indicate current and projected targets for rehabilitation

Secondary Aims

5. Identify baseline data requirements
6. Identify ongoing monitoring requirements

Tertiary Aims

7. Make recommendations on a monitoring methodology
8. Make recommendations toward a management strategy

1.2 Workshop Format

The *Loveday Basin Conceptual Model and Rehabilitation Workshop* was held as a two-day event examining the limiting factors and driving forces within the basin, and what affect these have on the rehabilitation potential of this site.

The afternoon of the first day was spent on-site examining the Loveday Basin's ecological condition, the various flow control structures surrounding the basin, and the condition of the adjacent, rehabilitated Mussels Lagoon Complex. The second day was held in Berri and facilitated by Mr. Ashley Greenwood (DWLBC). The morning session involved a series of informal presentations, aimed toward laying a framework for further discussions on the various disciplines.

These presenting delegates were

- Hydrology - Mr. David Cresswell (DWLBC)
- Sulfidic Sediments - Dr. Sebastien Lamontagne (CRC LEME)
- Aquatic/Riparian Flora - Dr. Daryl Nielsen (MDFRC) & Dr. Jason Nicol (SARDI)
- Fish - Mr. Jason Higham (PIRSA)
- Terrestrial Vegetation - Dr. Amy George (CRC FE/DWLBC) & Dr. Lisa Mensforth (DWLBC)

Although not present during the workshop, comments regarding groundwater inputs and concerns were later sought from Mr. Steve Barnett (DWLBC).

The subsequent sessions were open discussions aimed at identifying the limiting factors and driving forces within this basin, possible rehabilitation options, likely responses, and finally data and monitoring requirements. The results and opinions put forward in these discussions are presented in this report.

1.3 Summary

Three broad options were considered as potential management regimes that could be implemented at Loveday Basin.

1. Continue to operate as a disposal basin, managing for odour.
2. Create a means of regularly filling and flushing the basin, implementing a wetting and drying regime.
3. Create a permanent connection to the river incorporating relatively minor changes in water level and manage the basin to enable ongoing exchange between the basin and the river.

Continuing to operate this as a disposal basin provides no means of ecological rehabilitation. However if neither of the other options is feasible this may be the simplest method of odour control.

Option 2 could be considered a more traditional process of rehabilitating Loveday Basin, through the use of significant water level fluctuations, but was considered to incorporate an unacceptable risk of aggravating the sulfidic sediments present within the basin.

The third option was believed to be the most likely to provide a mechanism toward meaningful rehabilitation without exacerbating problems associated with existing salt loads and sulfidic sediments. This option will result in additional salt being flushed to the river initially, and possibly ongoing, which will require further assessment.

Map 1. Loveday Basin Location

Legend

Loveday Basin

N

25 12.5 0 25 50 75 100 Kilometers

Produced By: River Murray Group
Knowledge and Information Division
Department of Water, Land and Biodiversity Conservation

Projection: MGA Zone 54
Datum: Geocentric Datum of Australia 1994

PRIMARY LIMITING FACTORS

The primary limiting factors within the system were identified as
1. Existing salinity levels
2. Presence of sulfidic materials
3. Groundwater Inputs

These limiting factors exert an overwhelming influence on this wetland. While it is clear that these three processes do not completely explain the current limitations of this wetland, all other processes appear to be of minor consequence by comparison.

1.4 Existing salinity levels

The use of Loveday Basin as a salt disposal basin has, in part, led to the acquisition of significant quantities of salts within the basin’s sediments. This salt is currently stored in the wetland as precipitated salts in sediments (including gypsum, aragonite, halite, and many others) and also occur as dissolved salts in surface water and in sediment porewater.

This has created a hostile environment for the majority of biota that would naturally have occurred at this site. Any rehabilitation attempts at this site must address the need to remove this salt. A once-off flushing of this site will not remove all of the salts due to the variety of salt compounds present.

It is generally accepted that salinity levels of greater than 1000 mg/L will lead to decreased diversity in flora and fauna. While most wetland organisms associated with the River Murray are capable of withstanding considerable fluctuations in salinity, it is desirable that salinity levels be maintained below this threshold. Appendix 1 includes a table demonstrating a number of salinity thresholds currently believed to operate in most wetland environments.

1.5 Presence of sulfidic materials

“Sulfidic materials” are soils and sediments enriched in sulfide minerals like pyrite. They are often found in floodplain areas impacted by salinity, including saline disposal basins like Loveday Basin.

Sulfidic materials create conditions unsuitable to most plants and animals associated with sediments by maintaining a “reduced” environment (low oxygen concentrations in the sediments). In addition, sulfidic materials present a number of ecological and aesthetic risks when they are disturbed (that is, exposed to oxygen). These risks include deoxygenation of the water column, noxious smells, acidification of soil and water, release of toxic heavy metals and damage to infrastructure. Sediment resuspension and water level drawdowns are two ways by which sulfidic materials can be exposed to oxygen.

Sulfidic materials are currently widespread in the wet and dry areas of Loveday Basin – most notably in the wetter, northern half. While “potential acid sulfate soils” conditions are found locally, the basin as a whole appears to have a good buffering potential (through the significant quantities of carbonates present in the sediments). Whether the wetland is at risk of acidification during draw downs is currently being investigated by a CRC LEME/CSIRO project. Noxious odours have already been observed during low water levels at nearby properties which appear to be associated with the oxidation of sulfidic materials. Although it is not clear at this stage what compounds are responsible for these noxious odours and how they are produced exactly, it appears most likely that gas phase hydrogen sulfide and a variety of organic-S gases are contributors. It is also possible that the oxidation of organic-S compounds in the sediments (rather than sulfides) could be a source.

Current management of the noxious odour problem has been to raise the water level within the basin to ensure that the most affected areas are permanently inundated. This prevents the materials from oxidising, thereby reducing the production of noxious odours. Unfortunately, while this assists in removing the symptom it does not remove the underlying problem as the sulfidic materials continue to be present.

1.6 Groundwater Intrusion

Very closely linked to both of the previous issues, is the continuing intrusion of groundwater into the basin. In itself this is not a limiting factor. It is however a driving factor in the continued increase and exacerbation of both the salinity and sulfidic materials contained within Loveday Basin.

Historically (pre-European) it appears that the water level within Loveday Basin would have been perched (held above the natural river level), except during flooded periods when it would have been directly connected for, on average 2-3 months per year. The management of weir pool levels at an artificially high level and increases in irrigation in the highland areas has resulted in groundwater levels being maintained much closer to the Loveday Basin soil surface, significantly increasing groundwater intrusion at this site. The connection achieved during periods of flooding would have provided a natural means of regular flushing, which is no longer achieved due to the reduced flooding frequency of the Murray and the regulation applied to the channels entering and leaving the basin. This now means that salt and sulphur loads, from groundwater are increasing at a more rapid pace than would have occurred naturally.

2. CONCEPTUAL MODEL

A conceptual cross-section (Figure 1) from the highland areas through to the river was developed in order to demonstrate the movement of salt within the floodplain. In conjunction with this a basic conceptual salt, sulphur, and water balance (Figure 2) was developed using existing information and information derived from discussions during the workshop. While the quantity of salt contained within this system exerts considerable influence on sulphur loads, it was felt that explicitly defining the two separately was justified in order to emphasise these main areas of concern. Developing a highly detailed model incorporating both abiotic and biotic components (as initially proposed), was perceived to be beyond the required scope at this stage, as it would be based on a large number of potentially erroneous assumptions due to the near total influence that the primary limiting factors currently have on any ecological response. Until more is known regarding the effectiveness of remediation addressing these limiting factors, predicting ecological responses is largely guesswork. As such these basic models involving abiotic components were developed, followed by some comments regarding biotic components.

2.1 Abiotic Components

The resulting conceptual models clearly demonstrate a number of issues that need to be overcome before any meaningful attempts toward ecological rehabilitation can be undertaken.

2.1.1 ISSUES

- High existing salt and sulphur levels

The high salt and sulphur levels currently present within Loveday Basin pose a considerable impediment to any planned management program. Salinity levels will need to be reduced to more acceptable levels, and sulphur levels carefully managed during the early phases of such a program, before any ecological response is likely to occur.

- Significant ongoing salt and sulphur accumulation

The salt and sulphur contributions from the surrounding area, most notably the groundwater and highland irrigation drainage water components mean that simply removing the existing salt and sulphur will be insufficient. Figure 1 illustrates the large groundwater mound beneath the highland area that is creating upward pressure under the wetland/floodplain system, pushing the groundwater toward the basin surface. This is then further exacerbated by evaporation (especially in the dry southern lagoon) that also draws the groundwater toward the basin surface, concentrating any dissolved salt. In the northern lagoon the continuing return of brackish irrigation water further complicates this process of accumulation. Under current conditions the removal of existing salt and sulphur changes their baseline levels but not their trend, which is steadily increasing.

- No avenue for salt or sulphur discharge

The lack of any means to discharge salt or sulphur from this wetland means that it is continuing to operate as an evaporation basin. Therefore if significant portions of the existing salt and sulphur loads within the basin were removed and salt and sulphur inputs reduced, we would still not be solving the problem but rather buying time. The provision of a means for ongoing discharge of salt and sulphur loads needs to be the highest priority of any sustainable rehabilitation program.

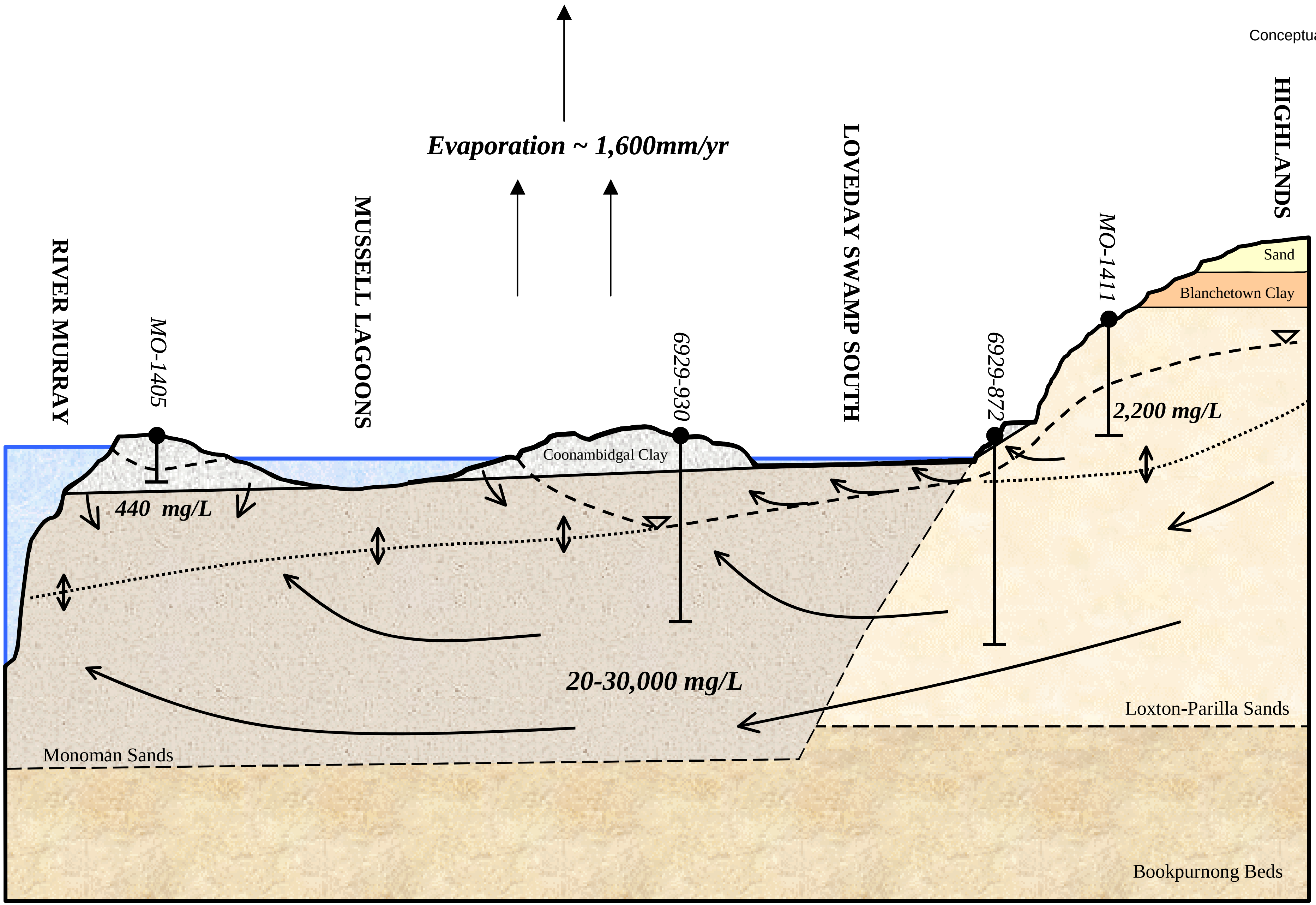


Figure 1. Loveday Basin Conceptual Salt, Water and Sulphur Balance

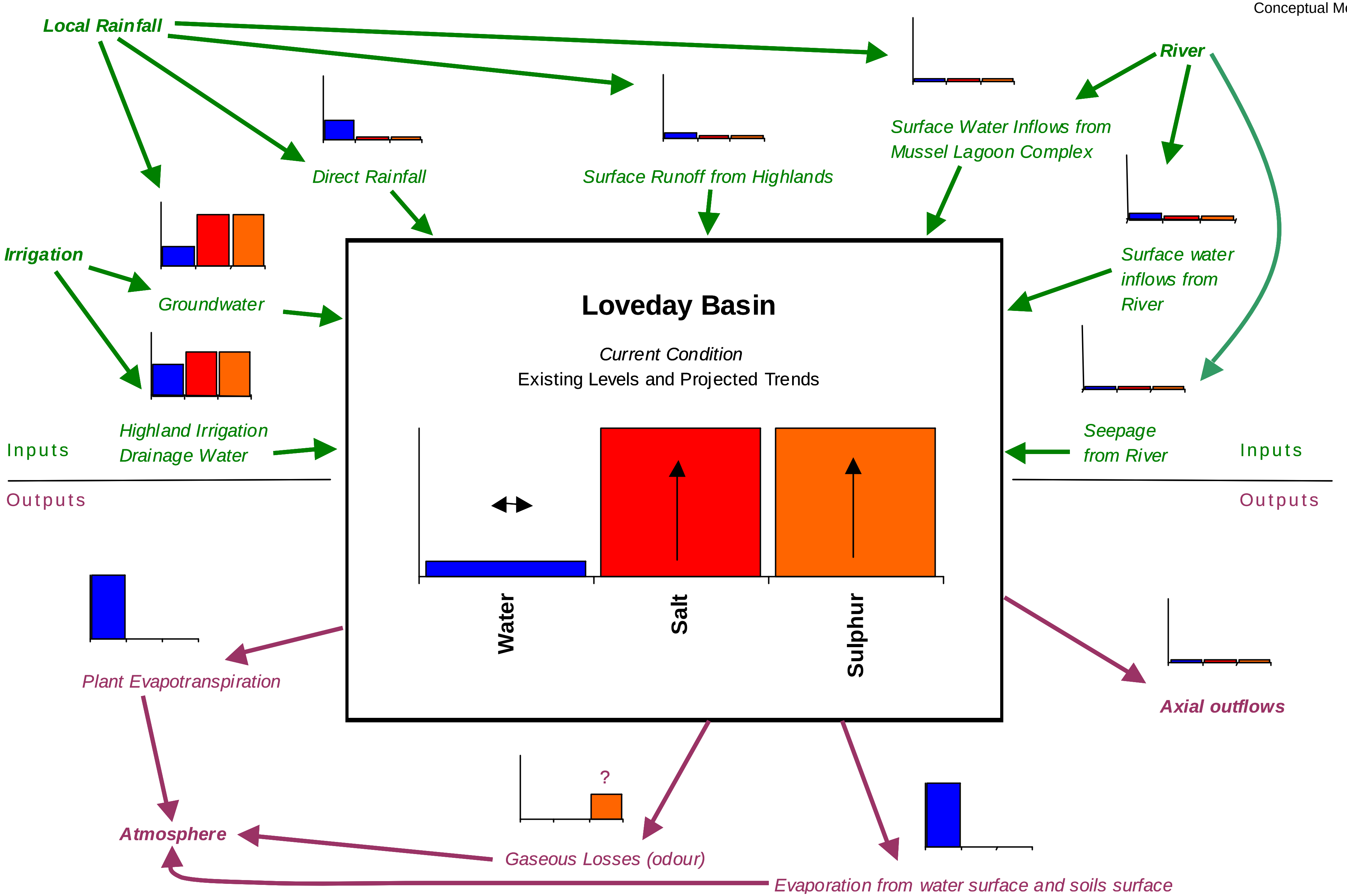


Figure 2. Loveday Basin Conceptual Cross-section

2.2 Biotic Components

Until the effectiveness of remediation to correct the current imbalance of the abiotic components is known, it is difficult to try and define any likely biotic trends. Thus biota was not included in any conceptual model or schematic at this time. However some comments on possible responses have been included. While this section is primarily aimed toward identifying the likely responses of biotic components within the basin it is worth noting that the rehabilitation of Loveday Basin would be expected to provide positive benefits to the river itself, if the initial salt slug is effectively managed.

2.2.1 AQUATIC/RIPARIAN VEGETATION

It is likely that once conditions are conducive to plant germination and growth there will initially be a slight delay in any response from the aquatic and riparian vegetation. This would be due to the reduced seed bank that is expected to be present within the basin's sediments. The sulfidic sediments and the highly saline soils are likely to have caused a reduction in the viability of many of the existing seeds. This is not likely to be a long-term problem as there is expected to be enough diversity within Mussels Lagoon and surrounding area for wind blown and waterborne seeds to provide effective recolonization. Unfortunately recolonization will almost certainly see significant weed growth, if so some form of weed management will be required.

Annually fluctuating water levels are preferable to static water levels, and more closely represent natural conditions. Due to the shallow profile of the basin, fluctuations as small as 5 cm may be sufficient, although greater changes would be preferable (this may not be possible due to the risk of oxidising sulfidic materials). Without significant drying, a 'bathtub ring' of vegetation surrounding the waters edge is likely to develop, however any fluctuations will maximise the area able to be used by this fringing vegetation. It is likely that these fluctuations will also go some way towards controlling the potential dominance of Typha. Given this likely eventuality some form of Typha management will need to be considered.

Once the primary limiting factors are effectively managed, ongoing water quality and quantity are likely to be the primary drivers of vegetation responses. It is unlikely that there will be any significant responses in the immediate future (1-2 years), rather responses would be expected to occur within 5 years of the implementation of any rehabilitation plan.

2.2.2 FAUNA

It is expected that most faunal groups (eg. macroinvertebrates, fish, birds etc.) will be capable of re-establishing viable populations under appropriate conditions. These conditions include good water quality, extensive and diverse vegetation communities, and reasonable water levels.

Macroinvertebrates are expected to face few impediments to their recolonization of Loveday Basin, as they will be capable of dispersing by air from nearby regions and through any connections to the river.

Small bodied generalist fish species (those capable of making use of both off-channel and in-channel habitats) are the most likely to make use of habitats within the basin. The presence of appropriate vegetation communities will be an important prerequisite for this to occur. Some small specialist fish species (those which only make use of off-channel habitats) may make use of these habitats, although they would take longer to initially reestablish and after any significant drying phases. Although ensuring there are no barriers to fish migration is important, the proposed vertical slot fishways appear to be unnecessary as these generally require at least a 500mm head difference between upstream and downstream water levels and enough flow to maintain such a structure. These structures are also aimed toward larger bodied species such as adult Golden Perch (*Macquaria ambiqua)* that are not likely to make use of the basin.

2.2.3 TERRESTRIAL VEGETATION

The existing terrestrial vegetation appears to be relatively tolerant of the basins current saline conditions, although there is a notable absence of living floodplain trees (*E. largiflorens*, *E. camaldulensis*). This indicates that there is limited value in including the larger terrestrial vegetation as part of the rehabilitation at this time. It may be possible to have some trees germinate around freshwater fringes but it is unlikely that these would survive to adulthood under the present conditions. Once the abiotic components of the basin are on path to successful rehabilitation it may be possible to consider the rehabilitation of terrestrial vegetation.

3. REHABILITATION OPTIONS

The rehabilitation of Loveday Basin is aimed towards re-establishing an effective self-sustaining ecosystem appropriate for a freshwater wetland. At this early stage this will be primarily aimed at the aquatic and riparian regions within the basin margin, although it is hoped that some improvements in terrestrial floodplain communities will also be possible as the condition of the basin improves.

Any efforts to rehabilitate Loveday Basin need to address the three primary issues as identified through the conceptual model, these being:

- No avenue for salt or sulphur removal
- High existing salt and sulphur loads
- Significant ongoing salt and sulphur accumulation

Unless an ongoing means of removing salt and sulphur from the wetland is implemented any rehabilitation program will not be successful. Any rehabilitation program also needs to remove the existing high salt and sulphur stores. If both of these are able to be effectively implemented it may balance the significant ongoing salt and sulphur inputs, although the reduction in these inputs would invariably assist in any rehabilitation attempts.

Seven primary management requirements need to be considered by any rehabilitation plan developed for this site (Table 1).

Table 1. Management Strategies for Loveday Basin

	Management Strategy	Reason	Importance
1.	Reduce wetland salt accumulation through ongoing exchange of salt and sulphur with an external agent (most likely through circulation of river water)	Without this the wetland will continue to become more hostile for biotic organisms.	Extremely High
2.	Manage the existing salt and sulphur stores towards reducing their impedance on the provision of freshwater	Without this the wetland will continue to be too hostile for most biotic organisms.	Extremely High
3.	Reduce oxidation of sulfidic sediments	Produces noxious odour unacceptable to local residents.	Extremely High
4.	Reduce ongoing salt and sulphur inputs	Unless an equilibrium can be reached through Management Requirement 1 this will result in the wetland continuing to become more hostile for biotic organisms.	Potentially High
5.	Avoid ongoing static water levels	Does not represent natural water level fluctuations, results in reduced floral diversity.	Moderate
6.	Ensure any regulatory features do not impede fish passage	Re-establishment of viable fish populations will not occur where barriers to fish passage exist.	Moderate
7.	Salt concentration is maintained below 1000 mg/L for the majority of every year	Widely accepted threshold above which biodiversity declines.	Moderate

Included below are a number of proposed rehabilitation options. Some of these could be used as stand alone options, however the most effective management is likely to be a synergy of complementary options.

3.1 Do nothing

Currently the basin is solely managed for odour control by ensuring that any sulfidic materials are permanently inundated. This means that the only avenue for water loss from the basin is through evaporation, with the losses being replaced by inflows from the Northern Inlet.

This management will continue the current trend of accumulating salt and sulphur loads within the wetland and would likely lead to a further reduction in biodiversity at this site. In the short-term this controls odour problems. In the long-term it is unknown how the continued build-up of sulfidic materials will affect ecological processes and odour production at the site.

3.1.1 ADVANTAGES

- Continues current odour management

3.1.2 DISADVANTAGES

- Does not solve any long-term problems or issues
- Does not provide any means of ecological rehabilitation (assumes that a worsening of ecological condition is acceptable).

3.1.3 MANAGEMENT REQUIREMENTS ADDRESSED

3. Reduce oxidation of sulfidic sediments

3.2 Permanent connection allowing for wind exchange

The simplest and most natural means for implementing an ongoing process of salt and sulphur removal from the wetland is to permanently open, and if necessary, expand the northern inlet. If the inlet were widened sufficiently it would allow wind-induced exchange of water between the river and the basin with salinity levels within the basin eventually reaching an equilibrium. It is hoped that this would reduce salinity significantly and in general maintain salinity levels below the 1000 mg/L threshold mentioned in Management Requirement 7. Whether this can be achieved by this method alone depends on the degree of wind exchange possible and the amount of salt entering the basin through groundwater and drainage inputs.

This rehabilitation option would provide for permanent inundation of sulfidic materials, reducing odour problems. However it is unclear how this will ultimately affect the build up of sulfidic materials although initially it is expected that this would continue to increase the sulfidic sediments, as initially the river water would bring more salt and sulphur. However as a more balanced equilibrium was found it is likely that this trend will be reversed with levels lowering in surface sediments in the longer term.

If an appropriate regulatory structure was placed across the Northern Inlet it would be possible to fluctuate the water level within the basin. This would allow the water level to be drawn down for a 2-3 month period every year.

3.2.1 ADVANTAGES

- Relatively simple solution
- Ongoing solution
- Maintains river connection allowing fish access (requires appropriate regulatory structures) and reintroduction of fauna through water borne propagules.

3.2.2 DISADVANTAGES

- Reinstates natural cycle of ongoing flushing to river (will increase salt returns to river)
- Will take time (potentially years) before salt levels come below 1000 mg/L

- Will create a static water level (unless a regulator is incorporated across the northern inlet)

3.2.3 MANAGEMENT REQUIREMENTS ADDRESSED

1. Reduce wetland salt accumulation through ongoing exchange of salt and sulphur with an external agent
2. Manage the existing salt and sulphur stores towards reducing their impedance on the provision of freshwater
3. Reduce oxidation of sulfidic sediments
5. Avoid ongoing static water levels (only through the construction of a regulator on the northern inlet)
7. Salt concentration is below 1000 mg/L for the majority of every year (Possibly in the longer-term)

3.3 Physical removal of sulfidic materials and salt loads

The physical removal of the surface sediments containing the majority of salt and sulphur stores may be feasible, although this does not remove the problems associated with the ongoing collection of salt and sulphur within the basin. This is less than desirable as a stand-alone method.

3.3.1 ADVANTAGES

- Relatively quick and immediate solution to existing salt and sulphur loads.

3.3.2 DISADVANTAGES

- It appears the materials are relatively homogenous meaning material across the entire basin would need to removed.
- This would almost entirely remove any viable seed bank (may be a minimal risk)
- This would change the bathymetry of the wetland creating deeper pools with steeper banks.
- These materials would need to be disposed of somewhere; this is not an easily solved problem for this volume of contaminated soil.
- Only solves the initial issues, would still require considerable ongoing management to ensure these conditions do not return.

3.3.3 MANAGEMENT REQUIREMENTS ADDRESSED

2. Manage the existing salt and sulphur stores towards reducing their impedance on the provision of freshwater
3. Reduce oxidation of sulfidic sediments (no longer of concern)
7. Salt concentration is below 1000 mg/L for the majority of every year (only provides a short-term solution as salt inputs are not addressed)

3.4 Upgrade of existing regulatory structures

All of the current structures around Loveday Basin would require some upgrading for them to be operated effectively. These structures need to be ‘fish friendly’ (that is they will provide neither a physical nor behavioural barrier to fish movement).

This can be achieved by

- Appropriate lighting through any closed structures eg. pipes or culverts as most fish will avoid extended regions of darkness.
- Sufficient roughness within structure floor and sides to provide varied flow especially areas of lower velocity (resting stations)
- Level with bed (no significant falls)
- Some effort to include Carp removal features should be considered

Further recommendations indicated that there was no justification for upgrading the Blackfellows Creek inlet to create a permanent connection. It is expected that this creek would have previously operated as a flood runner during higher flow periods. A complete survey along the channel is recommended to evaluate whether this was in fact the case. It is likely that this creek may have had an artificial sill installed across its width at some point to prevent connection at higher flows. If this is the case, this could be removed to allow occasional flooding flushes, however the amount of soil needed to be removed to create a permanent connection appears to be very substantial. This would be unwarranted considering water flowing through this creek enters the basin relatively close to the Mussels Lagoon inlet.

3.4.1 ADVANTAGES

- More effective regulation of inflows and outflows from Loveday Basin
- Increased fish access

3.4.2 DISADVANTAGES

- Cost

3.4.3 MANAGEMENT REQUIREMENTS ADDRESSED

5. Avoid ongoing static water levels (through increased flexibility of operation)
6. Ensure any regulatory features do not impede fish passage

3.5 Use pumps to move water around the Basin

The use of pumps would enable a greater level of control over the quantity of water entering and leaving the basin, and the locations where this occurs. One scenario would be to pump sufficient amounts of water into and out of the basin to achieve the hydrologic aims of option 6.2 (Permanent connection allowing for wind exchange). Similar to option 6.2 this would result in increased salt returns to the river. If it was feasible to pump this water elsewhere it may be possible to overcome this, although there is no obvious location to dispose of this water locally.

Pumps could also be used in conjunction with Option 6.2. A pump could be used to increase the quantity of river water entering the basin, creating a net loss of water through the northern inlet. Initially this could be particularly valuable where the flushing of sediment pore water is desired. If used in an ongoing manner this would also enable salinity levels within the basin to be maintained at a lower level than would be simply through wind exchange.

Alternative means of generating this circulation of water could be through the use of Blackfellows Creek or Mussels Lagoon inlet. Neither of these would be appropriate entirely with the potential uses of Blackfellows Creek discussed in Option 6.4. It is recommended that in the initial phases of this project Mussels Lagoon is only used to flush water into Loveday at times when it can be guaranteed that there will be no flow in the other direction. It is felt that allowing water to flow from Loveday Basin to Mussels Lagoon poses an unacceptable risk to the successfully rehabilitated Mussels Lagoon.

3.5.1 ADVANTAGES

- Greater flexibility especially in control of location and quantity of inflows and outflows from the basin

3.5.2 DISADVANTAGES

- Reduced natural connection to river
- Ongoing pumping may be set an inappropriate precedent to the community through the perception that natural connections are not necessary

3.5.3 MANAGEMENT REQUIREMENTS ADDRESSED

1. Reduce wetland salt accumulation through ongoing exchange of salt and sulphur with an external agent
2. Manage the existing salt and sulphur stores towards reducing their impedance on the provision of freshwater
3. Reduce oxidation of sulfidic sediments
5. Avoid ongoing static water levels
7. Salt concentration is below 1000 mg/L for the majority of every year

3.6 Redirect highland irrigation drainage water away from the basin

Currently one of the greatest inputs of salt and sulphur to this system is from highland irrigation drainage water. If this water could be redirected away from the basin it would significantly reduce the salt and sulphur loads entering the basin, resulting in less salt having to be flushed to the river. Due to improvements in irrigation efficiencies it is probably feasible to dispose of the drainage water to the Cobdogla Disposal Basin rather than using both basins.

3.6.1 ADVANTAGES

- Removes a major salt input at its source

3.6.2 DISADVANTAGES

- Shifting the problem as we are still building up salt loads elsewhere on the floodplain (regional concern not Loveday Basin specific).

3.6.3 MANAGEMENT REQUIREMENTS ADDRESSED

4. Reduce ongoing salt and sulphur inputs
7. Salt concentration is maintained below 1000 mg/L for the majority of every year

3.7 Intercept groundwater, reducing quantity entering the basin

The other significant input of salt and sulphur to this system is through groundwater intrusion. If it were possible to intercept a proportion of this groundwater prior to it entering the basin it would reduce the quantity of salt and sulphur accumulating within the basin, once again resulting in less salt being required to be flushed to the river.

3.7.1 ADVANTAGES

- Reduces one problem at its source

3.7.2 DISADVANTAGES

- Assumes that there is an reasonable location to discharge this water
- Shifting the problem as we are still building up salt loads elsewhere on the floodplain (regional concern not Loveday Basin specific).
- Expensive

3.7.3 MANAGEMENT REQUIREMENTS ADDRESSED

4. Reduce ongoing salt and sulphur inputs
7. Salt concentration is maintained below 1000 mg/L for the majority of every year (regional concern not Loveday Basin specific).

4. RECOMMENDED MANAGEMENT OPTION

All wetlands that have been isolated from the river are in the process of salinisation unless an alternative means of salt discharge has been implemented or occurs naturally. The pressure created by irrigation in upland regions often further exacerbates the salinisation process. The salt collecting in these basins is no longer being naturally removed through intermittent flooding or permanent river connections but rather held within the basin. In extreme cases the salinisation of these wetlands can lead to the development of sulfidic sediments, as has occurred in Loveday Basin. Rehabilitation of these wetlands cannot be successful unless these salts are removed.

There are two broad options for Loveday Basin:

- continue current management as an evaporation basin and accept the ecological implications, or
- implement a means of discharge. The recommended mechanism being through a permanent connection to the river.

If the latter option were chosen it would only be possible to achieve all of the rehabilitation management requirements through a synergy of the options mentioned in Chapter 5. All of these have some merit and justification, however it is through the use of a combination of these rehabilitation options that the greatest success is likely to be achieved.

This report proposes that

- The northern inlet be opened and widened allowing for wind exchange (Rehabilitation Option 6.2)
- Pumps are used in the short term to create a flushing cycle of salt returns to the river (Rehabilitation Option 6.5)
- Regulatory structures are upgraded to increase operational effectiveness and fish passage (Rehabilitation Option 6.4)
- Water levels are maintained at or near weir pool level for the majority of every year
- Water levels are fluctuated by 5 cm through pumping and inlet regulation for 2-3 months per year.

Map 2 demonstrates what would be required to achieve this at various locations throughout the Loveday Basin.

4.1.1 ADVANTAGES

- Provides mechanism for odour control
- Maintains river connection allowing fish access and reintroduction of fauna through water borne propagules
- Provides a mechanism for the ongoing removal of salt and sulphur stores from the basin

4.1.2 DISADVANTAGES

- Reinstates natural cycle of ongoing flushing to river (will increase salt returns to river)
- Ongoing pumping may set an inappropriate precedent to the community
- Requires ongoing management (self-sustaining populations likely to be many years away)

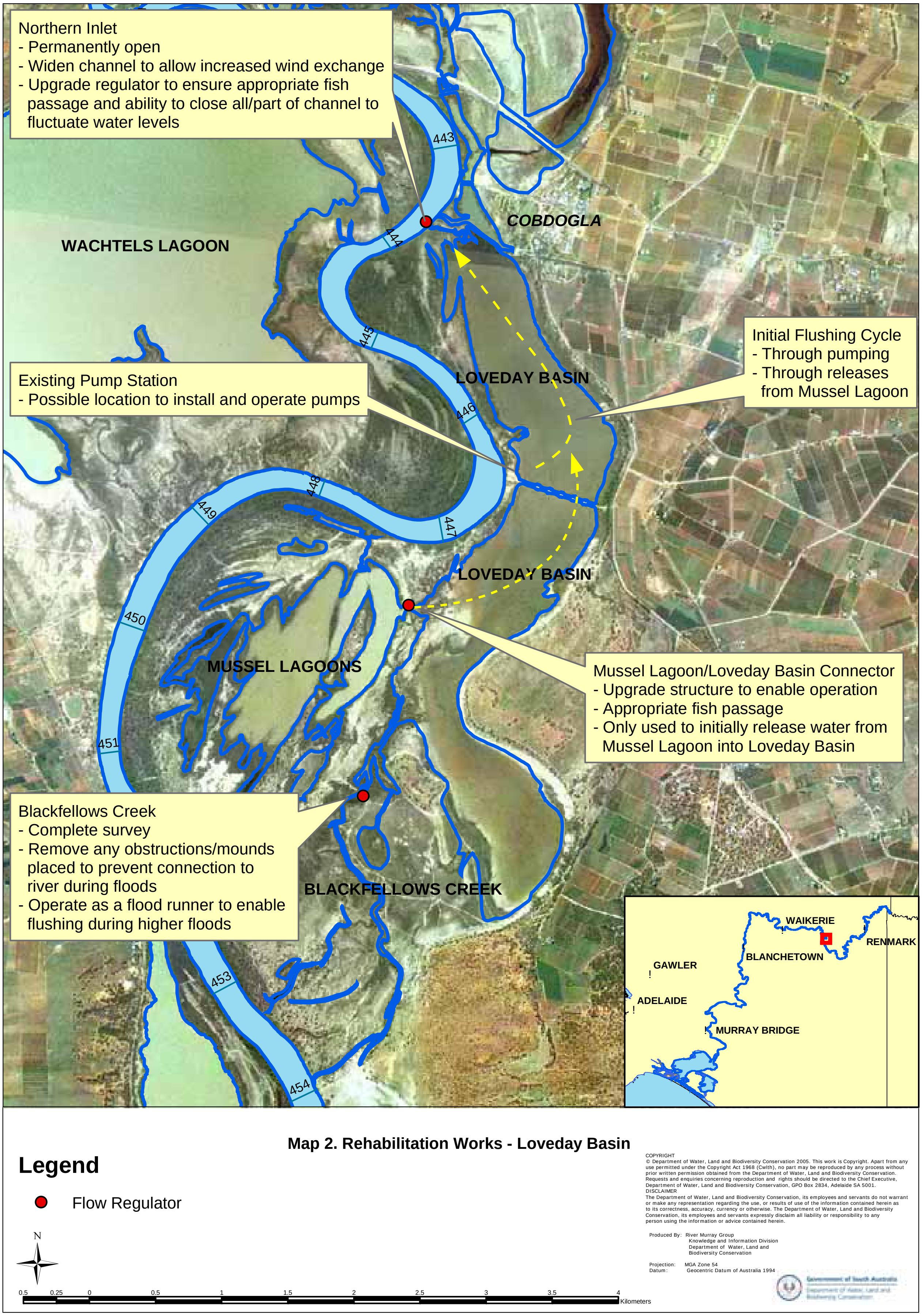
4.1.3 MANAGEMENT REQUIREMENTS ADDRESSED

1. Create an ongoing avenue for salt and sulphur removal
2. Removal of current high salt and sulphur stores
3. Do not allow oxidation of sulfidic materials
5. Avoid ongoing static water levels
6. Ensure any regulatory features do not impede fish passage
7. Salt concentration is below 1000 mg/L for the majority of every year (will need to be assessed)

Further management options that need to be considered include

- The removal of salt inputs, specifically highland irrigation drainage water and groundwater (Rehabilitation Options 6.6, 6.7)
- Pest management (Carp and weeds)
- Management of overly dominant species (*Typha* spp.)

It is also worth considering the possibility of concentrating rehabilitation efforts on the northern half of the basin (that region above the causeway). This is likely to allow more rapid improvement of this region with a greater rate of reduction in salinity. As the salinity in the northern section is reduced toward more acceptable levels, the southern end of the basin can then be allowed to connect. This is likely to extend the time required to rehabilitate the entire basin but will allow it to occur in a more manageable way.



Map 2. Rehabilitation Works - Loveday Basin

4.2 Expected Results

- Will create an initial salt slug
- Will increase salt load returned to river
- Will reduce salinity levels within basin
- Should reduce noxious odour problems
- Should promote plant growth and germination once salinity levels fall sufficiently
- Should enable smaller bodied generalist fish species to return once plant habitats are restored
- Will not see adult Murray Cod or Red Gums return in the near future
- Will result in an increase in weed species and exotic fish which will need to be managed

All of these responses are expected to occur in the section of basin north of the causeway. It is hoped that these responses will be seen in the southern section, but to what extent is dependent on the bathymetry of the basin. Sections that are not inundated at weir pool level, are not able to be inundated artificially at this time due to concerns regarding the maintainance of water levels above weir pool level, and the associated impact on groundwater levels. During floods these areas should now be naturally flushed.

Below is a list of native species that could take advantage of the Loveday Basin if rehabilitation measures were successful. This is not intended to be an exhaustive list, it is unlikely that all of those species listed will be present in the near future, and there may be some species not listed here that become established.

4.2.1 FISH SPECIES

- Australian Smelt (*Retropinna Semoni*)
- Carp Gudgeons (*Hypseleotris* spp.)
- Bony Bream (*Nematolosa erebi*)
- Galaxids (*Galaxias spp.*) – If present
- Juvenile Golden Perch (*Macquaria ambiqua*) – Potentially
- Hardyheads (*Craterocephalus* spp.)

4.2.2 OPEN WATER PLANT SPECIES

- *Myriophyllum* spp.
- *Vallisneria* spp.
- *Triglochin procerum*
- *Potamogeton* spp.
- *Azolla*
- *Lemna*
- *Chara*
- *Nitella*

4.2.3 WATERS EDGE PLANT SPECIES

- *Typha* spp.
- Common Reed *(Phragmites australis)*
- *Persicaria*
- Water Primrose *(Ludwigia peploides)*

- *Cotula*
- *Mimulus*
- *Bolboschoenus*
- *Myriophyllum* spp.
- *Juncus* spp.
- *Cyperus gymnocaulos*
- *Schoenoplectus*
- *Triglochin procerum*
- *Triglochin striatum*
- Various Floodplain herbs
- *Paspalum*

4.3 Further Investigations/Monitoring

To understand the implications of, and effectively implement the proposed management regime there are a number of investigations that need to be undertaken.

4.3.1 QUESTIONS

- *Is there a viable seed bank present?*

  A seed bank study is being undertaken by the Murray Darling Freshwater Research Centre (MDFRC). This study is investigating which plants germinate from soil cores collected from around the basin. Soils have been treated in two ways by wetting, and by wetting after flushing. Little is expected to germinate in the first instance, but it is hoped that some response will be noted in the second.

  While this information will not directly impact on initial management it will help us understand any subsequent responses. This information is also required when planning for weed control and the rehabilitation of vegetation communities.

- *Is there a feasible location where saline water can be disposed other than to the River?*

  There does not appear to be anywhere that the volume of water required to flush this system could be disposed of. This should be confirmed.

- *Is there a feasible location where sulfidic sediments can be dumped?*

  There does not appear to be anywhere that the volume of soil required to ensure all of the sulfidic sediments are removed, can be dumped. This should be confirmed.

- *What is the likely salt return to river, initially? And ongoing?*

  This will help us gain an understanding of the likely off-site impacts that any rehabilitation measure will incur.

- *What width of channel is required at the northern inlet to create the necessary wind exchange?*

The larger the channel required the greater the costs involved in building a regulator across this channel. However if this is too small the necessary interchange may not be possible, making it impossible to maintain sufficiently low salinity levels.

- *To what extent will sulfidic sediments deoxygenate sediment porewater in the littoral zone? What are the implications for plant germination and establishment?*

  Currently the greatest ecological cause for concern is the deoxygenation of the water column and to what extent this prevents plant germination in some of the fringing areas.

4.3.2 HYDROMETRIC MONITORING

To effectively understand and model what is occurring with regards to salt loads and water inputs and outputs we need to monitor

- Basin Water Level
- Groundwater levels
- Flow rates/amounts through regulators
- River Water Level near the Northern Inlet
- Evaporation rates, considering changes due to high salinities

4.3.3 WATER QUALITY MONITORING

- Continuous Basin: pH, O_2, Eh, Ec, temperature
- Monthly Basin: Major and minor ions, alkalinity, nutrients, dissolved metals
- Groundwater Ec, temperature
- River Ec, temperature near the Northern Inlet
- Drainage Water Ec, temperature

4.3.4 AIR MONITORING

- H_2S concentration
- SO_2 concentration

4.3.5 SOIL/SEDIMENT MONITORING

- EH Probes (Soil Redox)
- Annual Surveys (Sulphur quantity speciation, salinity, nutrients)

4.3.6 ECOLOGICAL MONITORING

To appropriately understand the effectiveness of rehabilitation attempts the following parameters need to be measured. It is recommended that some attempt be made to include Mussel Lagoon and the Main Channel in order to provide a wider perspective of general trends.

- Fish/Tortoise (possibly Spring/Autumn sampling using Fyke, Seine and Dip Nets)
- Vegetation (Transects, Photopoints, etc.)
- Macroinvertebrates
- Seed Bank Studies
- Chlorophyll a

APPENDIX 1. WATER DEPENDANT ECOSYSTEM - SALINITY THRESHOLDS

Editor: Glen Scholz; Senior Ecologist; DWLBC (2005)

Group	Taxa	Threshold EC (uS/cm)*	Threshold (mg/L) / (ppm)	Effect	Ref
Plants - Aquatic	Algae	>16,700	> 10,000	Majority of algae not tolerant	1
	Aquatic Plants	1,700-6,700	1,000 – 4,000	From significant impact on germination to upper tolerance limit (non halophytes)	1
	Most submerged Macrophytes	1,700-3,300	1,000 – 2,000	Sublethal effects, lethal for some	2,3
	Submerged stonewarts (Chara sp)	1,700-5,000	1,000 – 3,000	Disappear from wetlands	2
	Submerged stonewarts (Nitella sp)	1,700-8,300	1,000 – 5,000	Disappear from wetlands	2
	Dominant Macrophytes	6,700	4,000	Disappear from wetlands	2
	Microbial mat dominated system (see notes below)	>166,700	>100,000	Threshold between macrophyte or phytoplankton dominated and microbial mat dominated system	3
Plants - Riparian	Trees (Eucalypt, Melaleuca, Casuarina)	>3,300	> 2,000	Adverse effects	2,3
Animals – no exoskeleton	Small multicellular organisms (hydra, leeches, flatworms) Macroinvertebrates without impermeable exoskeletons		Not tolerant to elevation in salinity levels	Lethal	2
Macro-invertebrates	Macroinvertebrates – significant changes in community structure	<1,700 <5,000 >16,700	<1,000 <3,000 >10,000	Little ecological stress Most freshwater tolerant sp. Change less rapid above this level	1,2,3
	Macroinvertebrates – emergence	3,300	2,000	Significantly reduced emergence for most taxa	2
Fish	Juvenile fish pre-hardened eggs	3,300-7,500	2,000 - 4,500	Adverse effects	2
	Juvenile fish growth rate, survivorship	5,000-8,300	3,000 – 5,000	Optimal between these figures	2
	Adult fish	14,700-16,700	8,800 - 10,000	Most are tolerant to this level	2,3
Birds	Water bird broods (see notes below)	25,500	15,300	Majority found below this level	2

*EC to mg/L conversion 0.6, rounded to nearest 100 EC.

Definitions:
Reference: (1)
Fresh waters – are water bodies with salinities less than 3000 mg/L
Saline waters – are between 3,000 mg/L to 10,000 mg/L
Seawater – 35,000 mg/L

Notes:
Reference: (3)
"Davis et al. (2003)…. Identified three alternative states in shallow wetlands influenced by increasing salinity"

- Freshwater emergent macrophyte – dominated wetlands to;
- Submerged macrophyte or phytoplankton – dominated wetlands to;
- Microbial mat dominated systems

Reference: (2)
"Pulsed release of saline water into freshwater systems should be avoided as it is likely to cause higher mortality and loss of biodiversity in a system than does a slow build up to the same level."
" …flushes of freshwater to saline systems at inappropriate times may have a negative impact on biodiversity…"

"Waterbirds are directly dependent upon macrophytes (for food, nesting and cover) and invertebrates (for food). However these taxonomic groups are likely to be adversely affected at salinity levels well below those causing direct affects on waterbirds (Stolley et al.)"

References:

(1) Neilsen DL, Brock MA, Rees GN, Baldwin DS (2003) Effects of increasing salinity on freshwater ecosystems in Australia. Australian Journal of Botany, 51, 655-665.

(2) Kimberly RJ, Cant J, Ryan T (2003) Responses of freshwater biota to rising salinity levels and implications for saline water management: a review. Australian Journal of Botany, 51, 703 – 713.

(3) Hart BT, Lake PS, Webb JA, Grace MR (2003) Ecological risk to aquatic systems from salinity increases. Australian Journal of Botany, 51, 689 – 702.